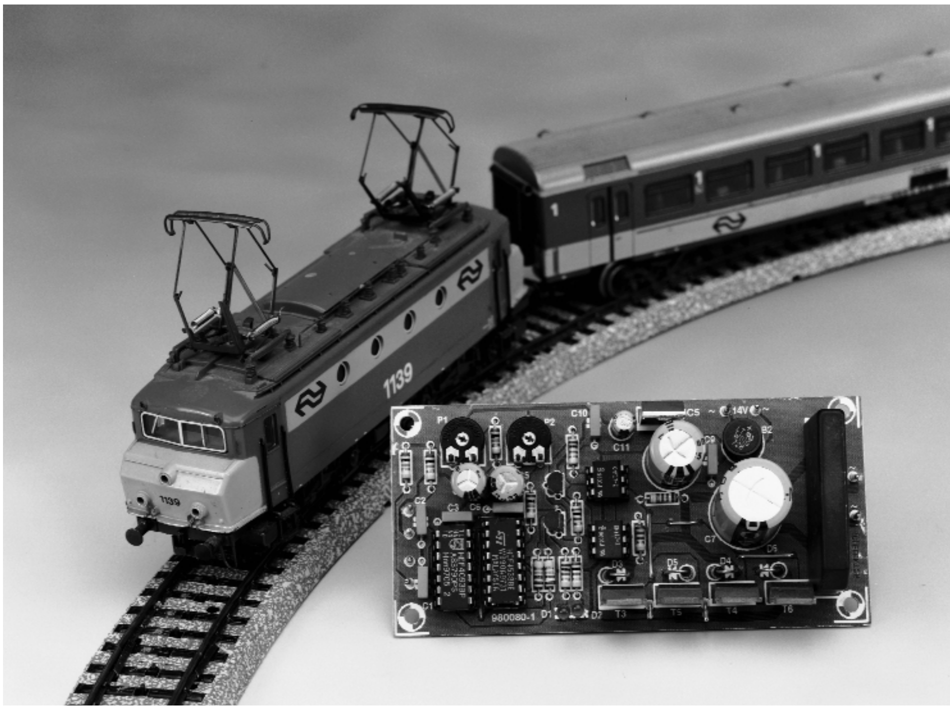
auto shuttle service for model railway

From A to B and back

The service provided by the circuit described in this article is known as a shuttle service (as for instance through the Channel tunnel between England and France – named Le Shuttle). It enables a train to travel to and fro between two stations without the necessity for a manual instruction. Compared with a number of other types of shuttle service, the present one has several interesting advantages.



An important advantage of the present circuit is that it does not require a change-over track or platform. The point in time when the polarity of the drive voltage of the train should be reversed is determined by two reed switches or relays in the track. This means that small magnets for operating these devices must be fitted (glued) to the underside of the locomotives used for shuttling between stations A and B.

Features:

- ✔ the distance between the two stations may be quite long
- ✔ the duration of the stop-over at each of the stations can be preset
- ✔ no run round loop required
- ✔ power lines of shuttle circuit and train are isolated
- ✔ wearfree electronic change-over of direction of travel
- ✔ standard, inexpensive components are used

Design by M. Metzner

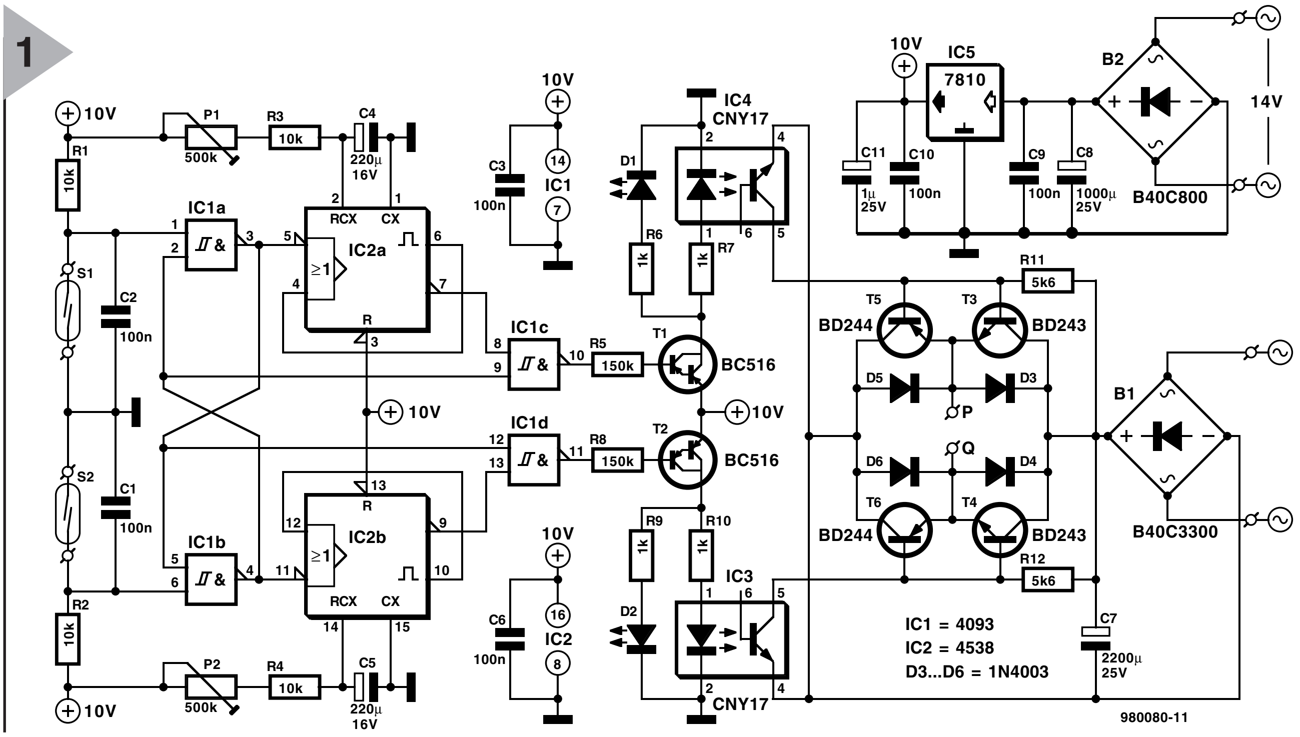


Figure 1. Circuit diagram of the shuttle track control. The direction of travel is reversed by power transistors T_3–T_6. The time the train remains at station A or B is set with P_1 and P_2 respectively.

CIRCUIT DESCRIPTION

To understand the function of the shuttle service circuit, imagine a train travelling from A to B. The train can move only when neither of timers IC$_{2a}$ and IC$_{2b}$ is set (see **Figure 1**). This is always so when the train is at a standstill at station A or B. Pin 3 of the bistable (flip-flop) formed by IC$_{1a}$ and IC$_{1b}$ is then logic low (0), whereas pin 4 is logic high (1). Pins 6 and 10 of IC$_2$ are also low, while pins 7 and 9 of IC$_2$ are high. The inputs of NAND gate IC$_1$ are high, but its output is low. This means that T$_1$ conducts whereupon the LED in optoisolator IC$_4$ lights. Power transistors T$_4$ and T$_5$ conduct and link the drive voltage to the rail track. The train is then able to leave station A and travel to station B.

When station B is approached, reed switch B closes when the locomotive passes over it. This causes bistable IC$_1$ to change state, whereupon pin 3 of IC$_1$ goes high, and pin 4, low. This results in the input (pin 11) of IC$_2$ being triggered, so that its normal output (pin 10) goes high at once and the inverted output (pin 9), low. The output of the NAND gate remains high, however, for as long as the timer is set. During this time, darlingtons T$_2$ and T$_2$, as well as the power circuit, T$_3$–T$_6$, remain cut off so that the train cannot leave station B.

When the time set by IC$_{2b}$ has elapsed, pin 9 of the timer goes high again, whereupon the inputs of NAND gate IC$_{1d}$ become high also, the output of the gate goes low, and T$_2$ conducts so that the LED in optoisolator IC$_3$ lights. Power transistors T$_3$ and T$_6$ then come on and connect the drive voltage with reverse polarity to the rail track. The train is then able to leave station B and travel to station A.

When station A is approached, reed switch A closes when the locomotive passes over it. This causes bistable IC$_1$ to change state again, whereupon a similar process as described for station B ensues. Now, however, timer IC$_{2a}$, which determines how long the train stops at station A, is triggered.

In this manner, the train travels continuously between the two stations (provided the power is switched on). Diodes D$_1$ and D$_2$ indicate which of the two optoisolators is enabled and therefore in which direction the train is travelling. When the train is at either of the two stations, both LEDs are out.

Because the inverse trigger inputs (pins 5 and 11) of IC$_2$ are used, timers IC$_{1a}$ and IC$_{1b}$ are triggered by the negative edges at pins 3 and 4 of IC$_1$. Since the timers change state after the set time has elapsed, even when the trigger inputs are low, operational errors are prevented. This is particularly important to avoid a fast moving locomotive closing the same reed switch twice in succession or a slow train stopping with the locomotive above the reed switch/relay and so keeping this closed.

The track voltage is derived from the normal railway power supply set as required for the track speed. The bridge rectifier, B$_1$, ensures that the supply to power transistors T$_3$–T$_6$ is of correct polarity at all times. Capacitor C$_7$ smooths the track voltage and short-circuits any spikes on it.

The supply voltage for the control circuit is derived from the normal railway lighting supply (14 V a.c.) via bridge rectifier B$_2$ and regulator IC$_5$.

CONSTRUCTION

The control circuit is best built on the printed-circuit board shown in **Figure 2**. Experienced constructors will have no problems in completing the board. Those with less experience should pay particular attention to the polarity of electrolytic capacitors, diodes, ICs, bridge rectifiers, and so on. Wire bridges also need close attention: make sure that these are soldered in place before any components are fitted.

Although, strictly speaking, power transistors T$_3$–T$_6$ do not need a heat sink during normal operation, it is wise to fit them on one to allow for any unforeseen events.

Circuit IC$_1$ should preferably be a Type 4093, which has high immunity to interference, but a Type 4011 (pin compatible with a 4093) may also be used.

When the power is switched on for the first time to the track and the con-

Parts list

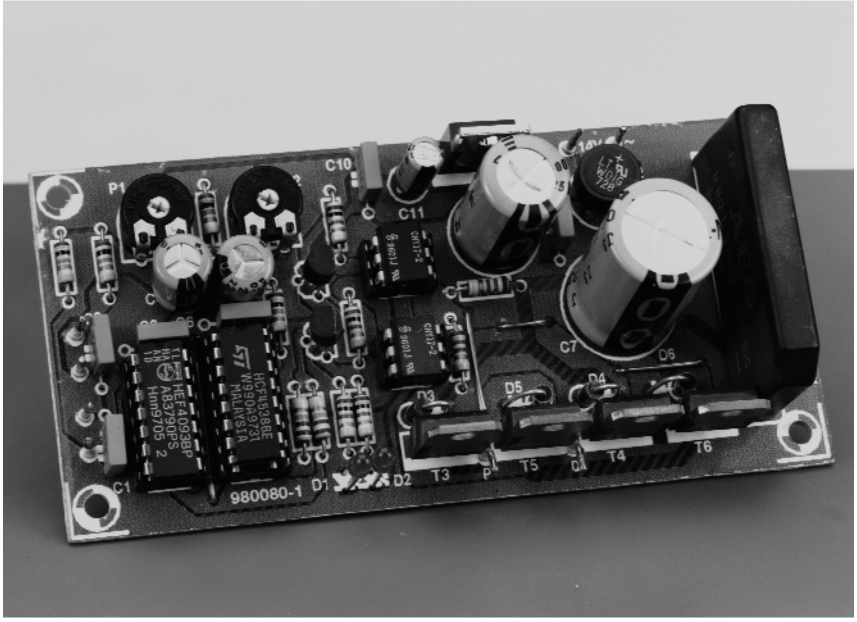
Resistors:
R_1–R_4 = 10 kΩ
R_5, R_8 = 150 kΩ
R_6, R_7, R_9, R_{10} = 1 kΩ
R_{11}, R_{12} = 5.6 kΩ
P_1, P_2 = 500 kΩ preset

Capacitors:
C_1–C_3, C_6, C_9, C_{10} = 0.1 μF
C_4, C_5 = 220 μF, 16 V, radial
C_7 = 2200 μF, 25 V, radial
C_8 = 1000 μF, 2 V, radial
C_{11} = 1 μF, 25 V, radial

Semiconductors:
B_1 = B40C3000 bridge rectifier
B_2 = B40C800 bridge rectifier
D_1, D_2 = LED, high efficiency
D_3–D_6 = 1N4003
T_1, T_2 = BC516
T_3, T_4 = BD243
T_5, T_6 = BD244

Integrated circuits:
IC_1 = 4093 or 4011 – see text
IC_2 = 4538
IC_3, IC_4 = CNY17-2
IC_5 = 7810

Miscellaneous:
S_1, S_2 = reed switch or reed relay
PC_1–PC_{10} = solder pins
PCB Order no. 980080 (see Readers services towards the end of this issue)



trol circuit, the timers are set by the negative edge at their inverse trigger inputs. Therefore, the train will not move until the relevant time has elapsed; at the first switch-on, this may take a little while.

If the train, on first switch-on, moves in the wrong direction and its passing over a reed switch has no effect, the polarity of the track voltage must be reversed.

Because the circuit is controlled via two reed switches or relays as opposed to via an isolating track, small magnets may be fitted (glued) underneath the last carriage instead of the locomotive. This enables the train to be fairly long while retaining the same distance between the front or rear of the train and the terminals of the shuttle track.

[980080]

See also 'Shuttle Track' in the July/August 1996 issue of this magazine.

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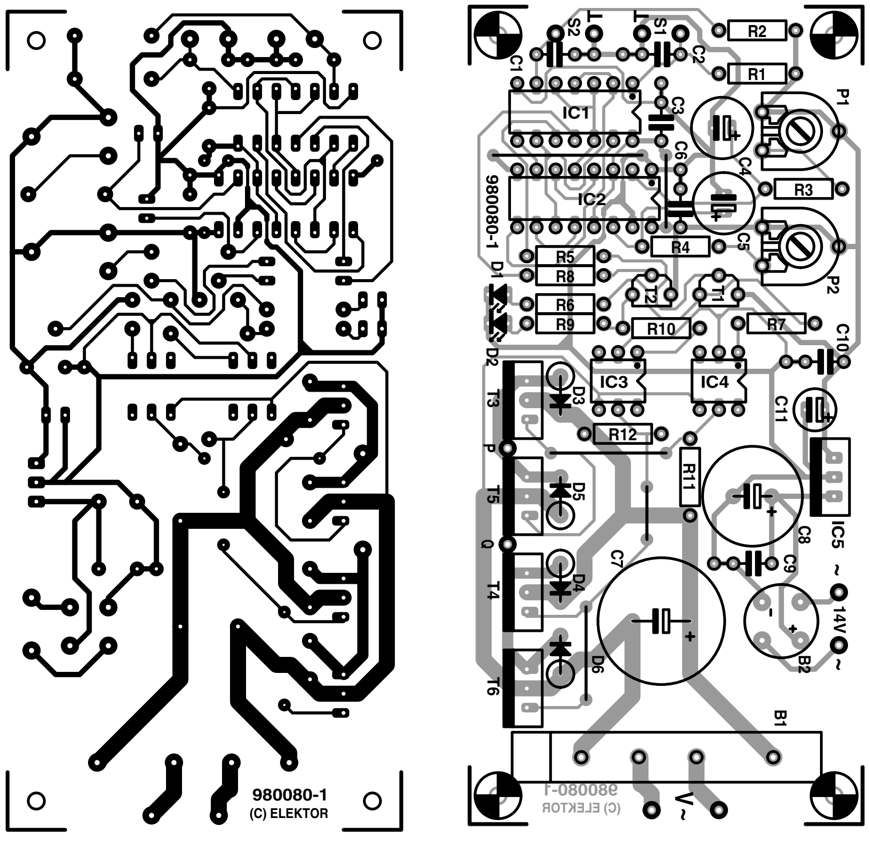

Figure 2. The printed-circuit board for the shuttle track control.